

Three New Species of *Procloeon* (Ephemeroptera: Baetidae) from Thailand

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ABSTRACT

Three baetid mayflies in the genus *Procloeon* Bengtsson are described from Thailand: *P. narumonae*, n. sp. (male and female adults and larva), *P. rubeosternum*, n. sp. (male and female adults, male and female subimagos, and larva), and *P. siamensis*, n. sp. (larva). Descriptions of known stages with line-drawings of diagnostic characters, material data, diagnoses, habitat data, and taxonomic remarks are provided.

Keywords: description, mayfly, larva, *Procloeon narumonae*, *Procloeon rubeosternum*, *Procloeon siamensis*

INTRODUCTION

The family Baetidae is one of the most diverse and widespread groups of mayflies, but members of the family have not been well known due to their small body size and lack of diagnostic characters in adults (e.g., reduction in wing venation and genitalia) (McCafferty and Waltz, 1990). The Baetidae fauna of tropical Southeast Asia has been studied by several mayfly taxonomists (Gillies, 1949; Ueno, 1969; Müller-Liebenau and Heard, 1979; Thomas, 1992; Boonsoong et al., 2004).

The baetid genus *Procloeon* Bengtsson is distributed throughout the world, but four species of the genus are recorded from the Oriental Region: *P. debilis* (Walker) from India (Kimmens, 1960; Hubbard and Peters, 1978), *P. tatualis* Waltz & McCafferty from Taiwan (Waltz and McCafferty, 1985), *P. regularum* Müller-Liebenau & Hubbards from Sri Lanka (Müller-Liebenau and Hubbard, 1985), and *P. spinosum* Nguyen & Bae from Vietnam (Tungpairojwong et al., 2006). *Procloeon debilis* is known from the adult only, and *P. regularum*, *P. tatualis*, and *P. spinosum* are known from the larva only. The purpose of this paper is to newly describe the species of *Procloeon* from Thailand.

MATERIALS AND METHODS

Field sampling was conducted from the northeastern area in

Thailand in 2006. Larvae and adults were collected using a hand net and a light trap, respectively. Adults were reared in the field using rearing cages. Habitat environmental parameters were measured while sampling was conducted. Sampled larvae and adults were preserved in 80% ethanol. Larval body parts such as mouthparts and gills were dissected, slide-mounted, and observed under a light microscope. Body parts measurements are in millimeters (mm). Most materials examined in this study are deposited in the Entomological Museum of Korea University (KU) in Seoul.

Abbreviations used in the materials examined are as follow: BB, Boonsatien Boonsoong; CB, Chaichat Boonyanusit; NT, Nisarat Tungpairojwong; PK, Paiboon Kettwongs; SS, Suparak Sawipak.

SYSTEMATIC ACCOUNTS

Order Ephemeroptera

Family Baetidae

Genus *Procloeon* Bengtsson

Type species: *Cloeon bifidum* Bengtsson

***Procloeon narumonae* Tungpairojwong & Bae, n. sp.
(Fig. 1)**

Material examined. Holotype: Male adult (labeled SWU-

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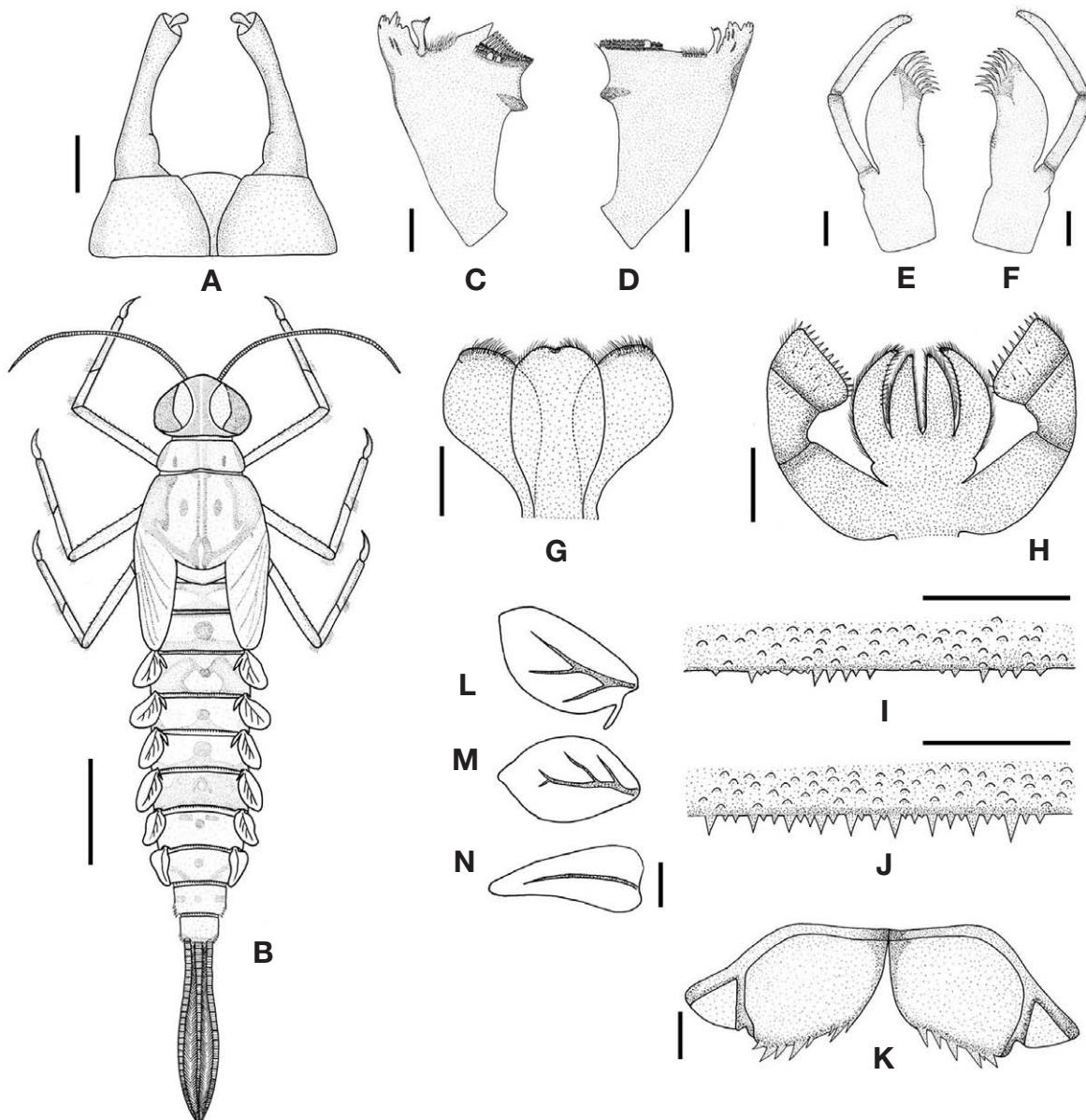


Fig. 1. *Procloeon narumonae*. A, Male genitalia (ventral); B, Larval habitus; C, Left mandible (dorsal); D, Right mandible (dorsal); E, Left maxilla (ventral); F, Right maxilla (ventral); G, Hypopharynx (ventral); H, Labium (ventral); I, Abdominal tergum I; J, Abdominal tergum V; K, Paraprocts; L–N, Gill V–VII. Scale bars: A, C–N=0.1 mm, B=1 mm.

EPH-3663, reared), Thailand, Sakhonnakhon Province, Phu Phan National Park, Huai Yai Waterfall, 17°01'16.9"N, 103°59'30.7"E, Elev. 270 m, 11 Jan 2006, BB, NT, PK, SS [KU]. Paratypes: 51 male adults (SWU-EPH-3664, by light trap), 3 female adults (SWU-EPH-3665, reared), and 17 female adults (SWU-EPH-3666, light trap), Loei Province, Loei River, Ban Non Pathana Village, 17°06'30.5"N, 101°28'51.4"E, Elev. 600 m, 19 Jan 2006, BB, CB, NT, SS [KU]. Other materials: 16 larvae (SWU-EPH-3667), same data as holotype;

type; 41 larvae (SWU-EPH-3668), same data as paratypes; 7 larvae (SWU-EPH-3669), Loei Province, Loei River, Ban Tao Tat Village, 16°57'47.7"N, 104°01'41.8"E, Elev. 520 m, 19 Jan 2006, BB, CB, NT, SS; 2 larvae (SWU-EPH-3670), Loei Province, Nam Jun Stream, Phu Luang Widlife Sanctuary, 17°20'19.7"N, 101°33'49.6"E, Elev. 360 m, 20 Jan 2006, NT, BB, CB, SS; 11 larvae (SWU-EPH-3671), Sakhonnakhon Province, Nam Pung River, 16°57'47.6"N, 104°01'41.9"E, Elev. 210 m, 12 Jan 2006, BB, NT, PK, SS; 2 larvae (SWU-

EPH-3672), Sakhonnakhon Province, Huai Bang Sai Noy Stream, Elev. 240 m, 12 Jan 2006, BB, NT, PK, SS; 13 larvae (SWU-EPH-3673), Chaiyaphum Province, Huai Thon Kai Stream, 16°05'44"N, 102°00'25.7"E, Elev. 490 m, 30 Jan 2006, BB, CB, NT, PK, SS; 14 larvae (SWU-EPH-3674), Chaiyaphum Province, Huai Mod Stream, 16°40'33.5"N, 101°44'36.7"E, Elev. 290 m, 24 Jan 2006, BB, CB, NT, PK, SS.

Description. Male adult (Holotype, in alcohol). Dimensions (mm): body length 6.40; antennae 0.62; longitudinal diameter of compound eye 1.10; cross diameter of compound eye 0.44; distance between compound eyes 0.19; height of dorsal compound eye 0.20; forefemora, foretibiae and foretarsal segments 1, 2, 3, 4 and 5 1.10, 0.82, 0.08, 1.00, 0.80, 0.46 and 0.20; midfemora, midtibiae and midtarsal segments 1, 2, 3, 4 and 5 1.06, 0.48, 0.08, 0.40, 0.20, 0.12 and 0.20; hindfemora, hindtibiae and hindtarsal segments 1, 2, 3, 4 and 5 1.00, 0.40, 0.38, 0.40, 0.20, 0.10 and 0.20; forewing length 6.90; forewing width 16.40; forceps segments 1, 2 and 3 0.08, 0.26 and 0.06; cerci 10.5. General body color light yellow to brown, with irregular reddish markings. Head: vertex with paired reddish line markings between compound eyes. Compound eyes turbinate; dorsal eyes light brownish ocher; ventral eyes grey. Ocelli dome-shaped, dull whitish, with circumferential black stripe. Antennae 3-segmented, light yellow to brownish; segment 3 brown. Thorax: prothorax brown; mesothorax light yellow, with one paired dark gray stripes submedially; metathorax light brown, with reddish markings; sterna entirely light yellow. Legs light brown. Forewings transparent, membrane hyaline without markings, and with single marginal intercalaries; longitudinal veins slightly yellowish; anterior area between C and R milky transparent; crossveins and adjoining membranes unpigmented. Hindwings absent. Abdomen: abdominal terga II–VI translucent; tergum I–IV and VII with light reddish irregular markings; terga II, VII–VIII somewhat deep reddish, with single white paired streaks submedially; tergum IV and VII with single pair of reddish stripes laterally; terga VII–X dull yellowish; terga I–IX with single reddish brown transverse stripe posteriorly; terga II–VI with black, longitudinal dashes along lateral margins in each segment; abdominal sterna light yellow, without markings. Genitalia (Fig. 1A) with 3-segmented genital forceps; segment 2 ca. 2.5 × length of segment 1; segment 3 < ca. 0.2 × length of segment 1; posterior margin of penes plate round. Cerci yellowish, with light brown joints, ca. 1.8 × length of body.

Female adult (in alcohol). Dimensions (mm): body length 5.7; antennae 0.79; forefemora, foretibiae and foretarsal segments 1, 2, 3, 4 and 5 0.70, 0.60, 0.10, 0.26, 0.10, 0.06 and 0.10; midfemora, midtibiae and midtarsal segments 1, 2, 3, 4 and 5 0.80, 0.72, 0.10, 0.20, 0.10, 0.06 and 0.12; hindfemora, hindtibiae and hindtarsal segments 1, 2, 3, 4 and 5 0.74,

0.32, 0.10, 0.20, 0.08, 0.06 and 0.10; forewing length 4.5; forewing width 1.70; cerci 6.30. General body color light yellow to brown, with irregular reddish markings. Head: vertex light brown, with one paired reddish stripes between compound eyes. Compound eyes dark brown. Ocelli dull yellowish, with circumferential black stripe. Antennae light yellow. Thorax: prothorax brown, with single paired reddish stripes submedially; mesothorax light yellow to brown, with one paired dark grey stripes submedially; metathorax brown, with irregular reddish markings; sterna entirely light yellow. Forewings transparent, without markings, with single marginal intercalaries; longitudinal veins yellowish brown; anterior area between C and R milky transparent; crossveins and adjoining membranes unpigmented. Hindwings absent. Legs light brown. Abdomen: abdominal terga I–X light yellow to brown; terga II–IX with reddish transverse stripe posteriorly; terga II–VIII with black, longitudinal dashes along lateral margins in each segment; tergum IV and VII with single pair of reddish stripes laterally; abdominal sterna light yellow. Cerci yellowish, with light brown joints, ca. 1.6 × length of body.

Mature larva (in alcohol). Dimensions (mm): body length 4.7–7.5; antennae 2.75; forefemora, foretibia and foretarsi 0.9, 0.54 and 0.57; midfemera, midtibiae and midtarsi 0.93, 0.53 and 0.57; hindfemora, hindtibiae and hindtarsi 0.88, 0.52 and 0.53; claws 0.29; cerci 1.87. General body color light yellow to brown with dark brown markings (Fig. 1B). Head: coloration light brown; vertex with one paired dark brown stripes medially. Antennae pale yellow, longer than width of head, ca. 4 × length of head capsule. Labrum with submarginal setae. Left mandible (Fig. 1C) with 9 blunt denticles on incisors, with field of hairlike setae next to prosthetica; molar area with two enlarged dentated tooth and series of small teeth. Right mandible (Fig. 1D) with 9 blunt denticles on incisors, with field of hairlike setae next to prosthetica; molar area with series of small teeth, with hairlike setae distally. Maxillae (Fig. 1E, F) with 2-segmented maxillary palp; maxillary palp terminal segment ca. 1.2 × length of segment 1, conical, and with scattered hairlike setae. Hypopharynx as in Fig. 1G. Labium (Fig. 1H) with V-shaped glossae; glossae slightly narrower than paraglossae, with rowed stout marginal setae; paraglossae with rowed stout marginal setae; labial palpi truncate, with stout marginal setae. Thorax: prothorax light yellow, with paired dark brown stripes medially on posterior margins; mesothorax light brown, with irregular dark brown markings; metathorax light brown; thoracic sterna white, with paired oblique dark brown markings near base of midlegs. Hindwingpads absent. Legs light yellow; femora with sparse stout setae anterior and posterior margins, with transverse arc of hairlike setae dorsoapically; tibiae light brown, with distinct arc of hairlike setae dorsobasally; tarsi

light brown, with scattered hairlike setae dorsally; claws light brown, relatively long, ca. $0.5 \times$ length of tarsi, and with two rows of minute denticles basally. Abdomen: abdominal tergum with row of spines on posterior margin, large and small spines alternating, greater in spine length in distal abdominal segments; tergum I light yellow, with irregular brown markings; terga II–IX with single dark brown spots medially, and with irregular brown markings laterally; tergum IV and VII somewhat lighter in color; tergum VI brown to dark brown in color, with single paired distinct oblique streaks; terga X light yellow; sternum IX with dark brown stripe along lateral margins; posterior margin I with acute spines (Fig. 1I, J); posterior margin X straight, with row of 16–20 acute spines (lateral spine enlarged); paraprocts (Fig. 1K) V-shaped, with 6–8 acute spines on distal half terga II–IX with posterolateral projections; lateral spines on tergum VIII ca. 3–5, and tergum IX ca. 3–5. Gills (Fig. 1L–N) present on abdominal segments I–VII, white, with well-developed tracheae; gill I–V each with dorsal flap; dorsal flap reduce in size; gill VI–VII single. Caudal filaments <ca. $0.3 \times$ length of body; ca. 2/3 basal part light yellow to brown and remaining distal part with dark brown bands; every 4th segment prominent, with whirl of simple stout setae, and with dark band at every 4th intersegmental membrane; cerci with row of long hairlike setae on inner side; terminal filament with row of long hairlike setae on both lateral sides.

Diagnosis. *Procloeon narumonae* can be distinguished from congeners by the combination of the following diagnostic characters. Adult: hindwings absent; tergum IV and VII with single pair of reddish stripes laterally. Larva: maxillae with 2-segmented maxillary palp; maxillary palp terminal segment ca. $1.5 \times$ length of segment 1; terga II–IX with large, dark brown spots medially; gills I–V double, dorsal flap reduce in size; lateral spines on tergum VIII–IX well developed; gills VI–VII single. *Procloeon narumonae* is similar in general morphology to *P. rubropictum* (McDunnough) from North America, but can be distinguished by the gill morphology in larva and round penile plate in genitalia in male adult.

Etymology. The specific name of this species, *narumonae*, is in honor of Prof. Narumon Sangpradub of Khon Kaen University in Khon Kaen who largely contributed to the science of aquatic entomology in Thailand.

Habitat. Larvae of *P. narumonae* were collected from the pool areas of slow-flowing permanent streams with abundant fallen leaves and marginal roots and macrophytes. The water and air temperatures in the collecting site (holotype) was 19–21.6°C and 22–30°C, respectively. The velocity was approximately 0.03–0.66 m/s. The water depth ranged 10–25 cm. The substrates mainly consisted of boulders mixed with cobbles, gravel, and sand on a large bedrock.

Remarks. This species is widely distributed throughout the

northeast areas in Thailand.

***Procloeon rubeosternum* Tungpairojwong & Bae, n. sp. (Fig. 2)**

Material examined. Holotype: male adult (labeled SWU-EPH-3675), Thailand, Sakhonnakhon Province, Phu Phan National Park, Huai Yai Waterfall, 17°01'16.9"N, 103°59'30.7"E, Elev. 270 m, 11 Jan 2006, BB, NT, PK, SS. Paratypes: 4 male adults (SWU-EPH-3676, by light trap) and 1 female adult (SWU-EPH-3678), same data as holotype. Other materials: 1 male subimago (SWU-EPH-3677, reared) and 5 female subimagos (SWU-EPH-3679, reared), same data as holotype. 34 larvae (SWU-EPH-3680), same data as holotype; 3 larvae (SWU-EPH-3681), Sakhonnakhon Province, Huai Bang Sai Noy Stream, Elev. 240 m, 12 Jan 2006, BB, NT, KP, SS; 1 larva (SWU-EPH-3682), Chaiyaphum Province, Huai Mod Stream, 16°40'33.5"N, 101°44'36.7"E, Elev. 290 m, 24 Jan 2006, BB, CB, NT, PK, SS; 3 larvae (SWU-EPH-3683), Loei Province, Nam Thob Stream, Phu Luang Wildlife Sanctuary, 16°40'33.5"N, 101°44'36.7"E, Elev. 330 m, 20 Jan 2006, BB, CB, NT, PK, SS.

Description. Male adult (Holotype, in alcohol). Dimensions (mm): body length 5.80; antennae 0.58; longitudinal diameter of compound eye 0.95; cross diameter of compound eye 0.47; distance between compound eyes 0.25; height of dorsal compound eye 0.38; forefemora, foretibiae and foretarsal segments 1, 2, 3, 4 and 5 1.22, 0.96, 0.09, 0.82, 0.58, 0.38 and 0.16; midfemora, midtibiae and midtarsal segments 1, 2, 3, 4 and 5 1.05, 0.65, 0.09, 0.40, 0.20, 0.18 and 0.15; hindfemora, hindtibiae and hindtarsal segments 1, 2, 3, 4 and 5 1.2, 0.6, 0.39, 0.42, 0.20, 0.10 and 0.19; forewing length 6.90; forewing width 6.40; hindwing length 0.70; hindwing width 0.12; forceps segments 1, 2 and 3 0.08, 0.23 and 0.05; cerci 7.85. General body color light yellow to brown, with reddish markings. Head: vertex light yellow, without markings. Compound eyes turbinate; dorsal eyes light yellow; ventral eyes light grey. Ocelli dull yellowish, with circumferential dark stripe. Antennae 3-segmented light brown; segment 3 darker. Thorax: prothorax light brown; mesothorax light yellow, with single paired chestnut brown vertical stripes medially; metathorax with reddish markings along suture posteriorly, and with paired dark reddish markings laterally; sterna light yellow, with irregular reddish markings; mesosternum with one paired deep reddish brown spots medially on anterior margin (Fig. 2A). Legs light yellow; coxae of midlegs and hindlegs with reddish spots; claws dark brown basally. Forewings transparent, membrane hyaline, and with single marginal intercalaries; longitudinal veins yellowish brown; anterior crossveins between C and R with small reddish markings. Hindwings (Fig. 2B) narrow and long, ca. $6 \times$ longer than

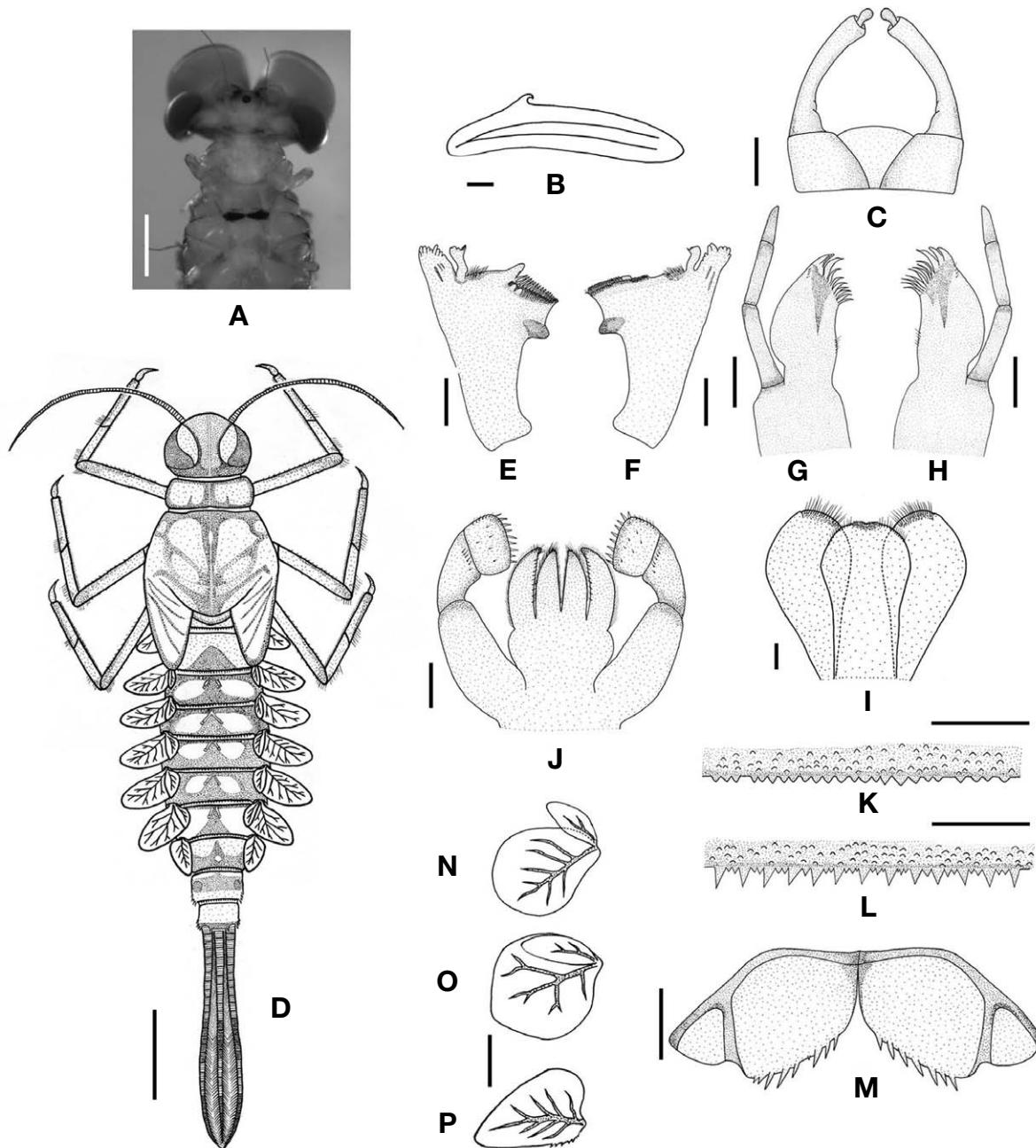


Fig. 2. *Procloeon rubeosternum*. A, Mesosternum; B, Hind wing; C, Male genitalia (ventral); D, Larval habitus; E, Left mandible (dorsal); F, Right mandible (dorsal); G, Right maxilla (ventral); H, Left maxilla (ventral); I, Hypopharynx (ventral); J, Labium (ventral); K, Abdominal tergum I; L, Abdominal tergum V; M, Paraprocts; N-P, Gill V-VII. Scale bars: A=0.5 mm, B, C, E-P=0.1 mm, D=1 mm.

wide, distal margin roundly pointed, and with two longitudinal veins; costal process curved at 1/3 basally. Abdomen: abdominal tergum I reddish; terga I–VI translucent; terga I–VIII with black, longitudinal stripes laterally; terga I–IX with reddish marginal transverse line posteriorly; tergum VII reddish, with single paired deep reddish markings laterally;

terga VIII–IX with scarlet reddish mark resembling round edged “M”; abdominal sterna light yellow to light brown, without markings. Forceps (Fig. 2C) yellowish, 3-segmented; segment 2 ca. $2.8 \times$ length of segment 1, segment 3 < ca. 0.6 × length of segment 1; posterior margin of penes plate broadly round. Cerci light yellow, ca. 1.4 × length of body.

Female adult (in alcohol). Dimensions (mm): body length 7.88; antennae 0.32; forelegs and midlegs broken; hindfemora, hindtibiae and hindtarsal segments 1, 2, 3, 4 and 5 1.0, 0.90, 0.12, 0.38, 0.18, 0.14 and 0.10; forewing length 6.00; forewing width 2.40; hindwing length 0.92; hindwing width 0.10; cerci broken.

General body color light yellow to brown. Head: compound eyes dark, without markings. Ocelli dull yellowish, with circumferential dark stripe. Antennae light brown, segment 3 darker. Thorax: prothorax and mesothorax light yellow, without markings; metathorax with reddish markings along suture posteriorly, and with single paired dark reddish markings laterally; mesosternum with one paired deep reddish spots submedially on anterior margin. Forewings transparent, membrane hyaline; longitudinal vein yellowish brown, and with single marginal intercalaries. Hindwings transparent. Legs light brown, without markings; joints between segments brown. Abdomen: abdominal terga light brown; abdominal terga II–IX with black, longitudinal dashes along lateral margins in each segment; terga I–IX with reddish marginal transverse line posteriorly.

Male subimago (in alcohol). Dimensions (mm): body length 6.30; antennae 0.88; longitudinal diameter of compound eye 0.66; cross diameter of compound eye 0.54; distance between compound eyes 0.20; height of dorsal compound eye 0.40; forefemora, foretibiae and foretarsal segments 1, 2, 3, 4 and 5 1.22, 0.96, 0.09, 0.82, 0.58, 0.38 and 0.16; midfemora, midtibiae and midtarsal segments 1, 2, 3, 4 and 5 1.05, 0.65, 0.09, 0.40, 0.20, 0.18 and 0.15; hindfemora, hindtibiae and hindtarsal segments 1, 2, 3, 4 and 5 1.2, 0.6, 0.39, 0.42, 0.20, 0.10 and 0.19; forewing length 8.00; forewing width 5.50; hindwing length 0.64; hindwing width 0.10; forceps segments 1, 2, and 3 0.10, 0.2 and 0.06; Cerci broken. General body color light yellow. Head: compound eyes turbinate; dorsal eyes light yellow; ventral eyes light grey. Ocelli dull yellowish, with circumferential dark stripe. Antennae 3-segmented, light brown, segment 3 darker. Thorax: prothorax light yellow; metathorax with paired chestnut brown spots laterally; sterna yellowish. Legs light brown, without markings; mesosternum with paired chestnut brown spots medially on anterior margin. Forewings light brown, with single marginal intercalaries; longitudinal veins yellowish brown; area between C and R dull yellowish. Hindwings narrow and long, ca. $8.5 \times$ longer than wide, with two longitudinal vein; costal process curved. Abdomen: abdomen light yellow, abdominal terga II–IX with black, longitudinal dashes along lateral margins in each segment. Genitalia yellowish.

Female subimago (in alcohol). Dimensions (mm): body length 7.2; antennae 0.82; forefemora, foretibiae and foretarsal segments 1, 2, 3, 4 and 5 1.06, 0.82, 0.08, 0.46, 0.14, 0.12 and 0.14; midfemora, midtibiae and midtarsal segments 1, 2,

3, 4 and 5 1.00, 0.64, 0.10, 0.24, 0.14, 0.10 and 0.16; hindfemora, hindtibiae and hindtarsal segments 1, 2, 3, 4 and 5 1.04, 0.70, 0.10, 0.26, 0.10, 0.06 and 0.16; forewing length 8.00; forewing width 3.00; hindwing length 0.50; hindwing width 0.06; cerci broken. General body color brown. Head: compound eyes grey, without markings. Ocelli dull yellowish, with circumferential dark stripe. Antennae light brown, segment 3 darker. Thorax: prothorax and mesothorax light yellow, without markings; metathorax light brown, with paired chestnut brown spots laterally. Forewings brownish, with longitudinal vein yellowish brown, and with single marginal intercalaries. Hindwings yellowish; costal process curved at ca. 1/4 basally. Legs light brown, without markings; joints between segments brown. Abdomen: abdominal terga light brown; abdominal terga II–IX with black, longitudinal dashes along lateral margins in each segment.

Mature larva (in alcohol). Dimensions (mm): body length 4.0–7.0; antennae 1.80–2.35; forefemora, foretibia and foretarsi 0.9, 0.47 and 0.47; midfemera, midtibiae and midtarsi 0.89, 0.47 and 0.47; hindfemora, hindtibiae and hindtarsi 0.9, 0.46 and 0.46; claws 0.23; cerci 2.20–2.40. General body color light yellow to brown with dark brown markings (Fig. 2D). Head: coloration light yellow to brown in vertex with paired dark brown stripes submedially. Antennae pale yellow, longer than width of head, ca. $3 \times$ length of head capsule. Labrum with submarginal setae. Left mandible (Fig. 2E) with 9 blunt denticles on incisors, with field of hairlike setae next to prosthetica; molar area with two enlarged dentated tooth and series of small teeth. Right mandible (Fig. 2F) with 9 blunt denticles on incisors, with field of hairlike setae next to prosthetica; molar area with series of small teeth, with hair-like setae distally. Maxillae (Fig. 2G, H) with 3-segmented maxillary palp; maxillary palp terminal segment $0.5 \times$ length of segment 2, apically conical; lacinia with single enlarged acute tooth, depressed near apex. Hypopharynx as in Fig. 2I. Labial palpi (Fig. 2J) truncate, with stout marginal setae. Thorax: Prothorax light brown, with paired J-shaped dark brown markings submedially on posterior margins; mesothorax light brown, with irregular dark brown markings; sterna white, with oblique dark brown markings near base of midlegs and hindlegs. Hindwingpads present and reduced in size. Legs light yellow to brown, apically darker in color; femora with sparse stout setae on anterior and posterior margins, with transverse arc of hairlike setae dorsoapically; tibiae light brown, with distinct arc of hairlike setae dorsobasally; tarsi light brown, with scattered hairlike setae dorsally; claws brown, relatively long, ca. $0.5 \times$ length of tarsi, with two rows of minute denticles basally. Abdomen: abdominal tergum with row of spines on posterior margin, large and small spines alternating, greater in spine length in distal abdominal segments; tergum I light yellow, without mark-

ings; tergum II with medial dark brown “ \cap ” mark on posterior margin; terga III and VI dark brown, with paired pale yellow areas submedially, and with paired white streaks on anterior margin medially; terga IV–V with longitudinal dark brown markings on anterior margin, with medial dark brown “ \cap ” mark on posterior margin, and with paired white streaks on anterior margin medially; tergum VII light yellow, with longitudinal dark brown stripe on anterior margin; tergum IX irregular markings; tergum 10 light yellow, without markings; sterna II–IX with dark brown stripes along lateral margins; sternum IX somewhat darker; posterior margin of tergum I (Fig. 2K) with broadly, blunt spines; posterior margin of terga V (Fig. 2L) with acute spines; posterior margin of tergum X straight, with row of 20–22 acute spines (lateral spine enlarged); terga II–IX with posterolateral projections; lateral spines on tergum VIII ca. 1–2, tergum IX ca. 4–6; paraprocts (Fig. 2M) V-shaped, with 7–9 acute spines on distal half. Gills (Fig. 2N–P) present on abdominal segments I–VII, white, with well-developed dark brown tracheae; gill I–VI each with small dorsal lemella; dorsal lamella smaller, ca. $0.5 \times$ width of lower lamella; gill VII single, with ca. 7 spines on posterobasal margin. Caudal filaments $<0.5 \times$ length of body, with broad dark band at mid-length, with pale yellowish bands $<1/4$ of cerci, and with dark brown bands distally; every 4th segment prominent, with whirl of simple stout setae, and with dark band at every 4th intersegmental membrane; cerci with row of long hairlike setae on inner side, terminal filament with row of long hairlike setae on both lateral sides.

Diagnosis. *Procloeon rubeosternum* can be distinguished from congeners by the combination of the following diagnostic characters. Adult: hindwings present, reduce in size; metathorax with paired dark reddish brown spots laterally; mesosternum with paired reddish brown spots medially on anterior margin. Larva: lacinia of maxillary with single enlarged acute tooth, depressed near apex; maxillary palp terminal segment ca. $0.5 \times$ length of segment 2, apically conical; lateral spines on tergum VIII poorly developed, with 1–2 spines; terga III and VI with one pair of white streaks on anterior margin submedially. The larva of *P. rubeosternum* is similar to *P. spinosum* from North America in general morphology, but can be distinguished by the relative length of the terminal segment of maxillare palp, single enlarged acute tooth in lacinia of maxillae, and color pattern of caudal filaments.

Etymology. The specific name of this species, *rubeosternum* (Latin) is from a combination of *rubeo* (red) and *sternum*, an allusion of the mesosternum with paired dark reddish spots medially on the anterior margin.

Habitat. The larvae of *P. rubeosternum* occurred in mountain streams ranging 240–330 m in altitude. The larvae were found from slow-flowing pool areas in the streams with abundant

fallen leaves and algae. The water and air temperatures in the holotype collecting site were 19–22°C and 21.5–29°C, respectively. The velocity of the site was approximately 0.07–0.66 m/s. The water depth ranged 5–20 cm. The substrates mainly consisted of boulders, cobbles, and gravel on a bedrock.

Remarks. This species is widely distributed throughout the northeast area in Thailand.

***Procloeon siamensis* Tungpairojwong & Bae, n. sp.
(Fig. 3)**

Material examined. Holotype: mature male larva (labeled SWU-EPH-3684), Thailand, Petchabun Province, Nam Nao National Park, Yakruea Stream, 16°44'17.6"N, 101°34'20.4"E, Elev. 810 m, 23 Jan 2006, BB, CB, NT, PK, SS [KU]. Paratypes: 87 larvae (SWU-EPH-3685), same data as holotype.

Description. Mature male larva (Holotype, in alcohol). Dimensions (mm): body length 8.30; antennae 2.45; forefemora, foretibia and foretarsi 1.23, 0.71 and 0.78; midfemora, midtibiae and midtarsi 1.20, 0.67 and 0.77; hindfemora, hindtibiae and hindtarsi 1.19, 0.64 and 0.74; claws 0.32; cerci 3.21. General body color light yellow to brown with dark brown markings (Fig. 3A). Head: coloration light brown in vertex with paired dark brown stripes submedially. Antennae pale yellow, longer than width of head, ca. $2.5 \times$ length of head capsule. Labrum with submarginal setae. Left mandible (Fig. 3B) with 9 blunt denticles on incisors, with field of hairlike setae next to prothetica; molar area with two enlarged dentated teeth and series of small teeth. Right mandible (Fig. 3C) with 7 blunt denticle on incisors, with field of hairlike setae next to prothetica; molar area with series of small teeth, with hairlike setae distally. Maxillae (Fig. 3D, E) with 3-segmented maxillary palp; maxillary palp terminal segment ca. $0.5 \times$ length of segment 2, slightly depressed near apex (Fig. 3F). Hypopharynx as in Fig. 3G. Labium (Fig. 3H) with V-shaped glossae; glossae slightly lower than paraglossae, with rowed stout marginal setae; paraglossae with rowed stout marginal setae; labial palpi broadly truncate, with stout marginal setae. Thorax: prothorax light brown, with J-shaped dark brown markings submedially; mesothorax light brown, with irregular dark brown markings; metathorax brown; thoracic sterna white, without markings. Hindwingpads present, reduced in size. Legs light yellow to brown, apically darker in color; femora with sparse stout setae anterior and posterior margins, with transverse arc of hairlike setae dorsoapically; tibiae light brown, with distinct arc of hairlike setae dorsobasally; tarsi light brown, with scattered hairlike setae dorsally; claws brown, relatively long, ca. $0.5 \times$ length of tarsi, and with two rows of minute denticles basally. Abdomen: abdominal

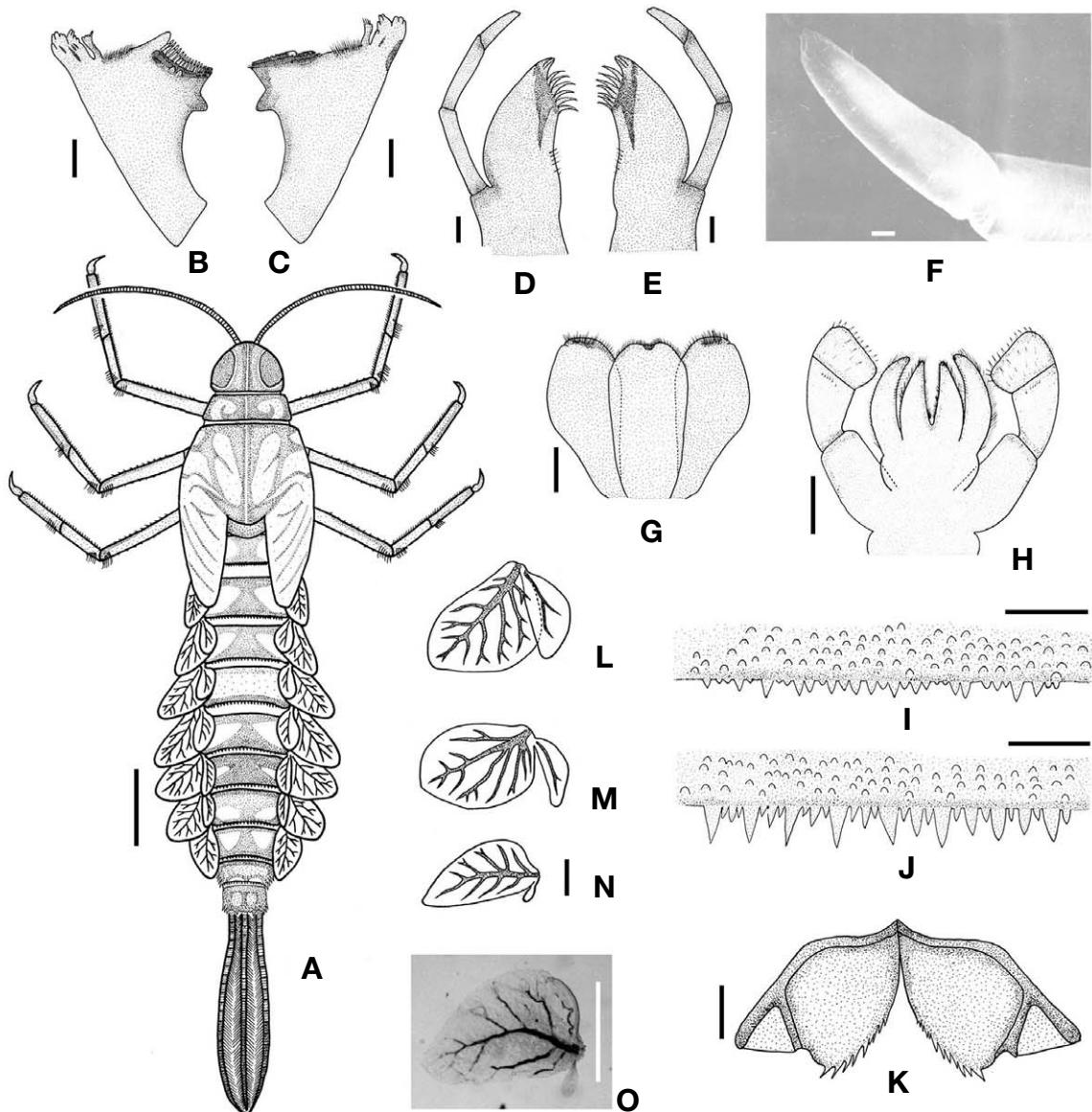


Fig. 3. *Procloeon simensis*. A, Larval habitus; B, Left mandible (dorsal); C, Right mandible (dorsal); D, Right maxilla (ventral); E, Left maxilla (ventral); F, Terminal segment of maxillary palp; G, Hypopharynx (ventral); H, Labium (ventral); I, Abdominal tergum I; J, Abdominal tergum V; K, Paraprocts; L-N, Gill V-VII; O, Gill VII with a small outgrowth process. Scale bars: A=1 mm, B-E, G-N=0.1 mm, F=10 µm, O=0.5 mm.

terga with row of spines on posterior margin, large and small spines alternating, greater in spine length in distal abdominal segments (Fig. 3I, J); terga I–VIII with rectangular dark brown markings on anterior margin, with medial dark brown “ \wedge ” mark posteriorly, and with one pair of submedial pale area; terga I and XI somewhat darker in color; terga IV and VII somewhat lighter in color; terga IX, and X dusky, with poorly defined pale area; abdominal sterna II–IX with dark brown stripe along lateral margins; sternum IX somewhat darker; posterior margin of tergum X straight, with row of

19–20 large acute spines on distal half (lateral spines enlarged); paraprocts (Fig. 3K) V-shaped, with 7–12 acute spines on distal half; terga II–IX with posterolateral projections; number of lateral spines on tergum VIII ca. 1–2, tergum IX ca. 3, less than ca. 1/3 \times length of abdominal tergum. Gills (Fig. 3L–N) present on abdominal segments I–VII, white, palm-like, round apically, and with well-developed tracheae; gills I–VI each with dorsal lamella; dorsal lamella smaller in size, < ca. 0.5 \times width of ventral lamella; gills VII single, with small outgrowth process; ratio of lamella gill vs. small

outgrowth process 0.84 vs 0.19 in length (Fig. 3O); marginal gill with scattered minute spines. Caudal filaments <0.4 × length of body, with broad brown bands at mid-length; every 4th segment prominent, with whirl of simple stout setae, and with dark band at every 4th intersegmental membrane; cerci with row of long hairlike setae on inner side; terminal filament with row of long hairlike setae on both lateral sides.

Diagnosis. The larva of *Procloeon siamensis* can be distinguished from congeners by the combination of the following diagnostic characters: terminal segment of maxillary palp slightly depressed near apex, 0.5 × length of segment 2; gills palm-like; lateral spines of tergum VIII ca. 1–2; gill VII with a small outgrowth process. The larva of *P. siamensis* is similar to *P. tattualis* from Taiwan in general morphology, but can be distinguished by the slightly depressed terminal segment of maxillary palp near apex, and palm-like gills with ramified tracheae on dorsal flaps of gills V and VI. From our materials examined, 81 larvae possessed simple gill VII and remaining 6 larvae possessed an additional small outgrowth process on gill VII.

Etymology. The specific name of this species, “*siam*” (noun), refers to Thailand.

Habitat. The larvae of *P. siamensis* were collected from the pool areas of slow-flowing permanent streams with abundant fallen leaves and marginal vegetation. The water and air temperatures from the holotype collecting site were 17°C and 22°C, respectively. The velocity was approximately 0.03 m/s and the water depth ranged 7–15 cm. Substrates mainly consisted of boulders mixed with cobbles, gravel, sand, and fallen leaves on a large bedrock.

Remarks. We collected abundant larvae of this species from the Yakraue Stream in Nam Nao National Park. Rearing was not successful at that time.

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